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PATENT SPECIFICATION (11) 1 409 150

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(54) PROSTHETIC IMPLANT FOR A KNEE JOINT

(71) We, SULZER BROTHERS LIMITED, a Company organised under the Laws of Switzerland, of Winterthur, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to prosthetic implants for knee joints.

Two essential requirements in medical terms must be observed in designing prosthetic implants. Firstly, the movement of the prosthesis should correspond as closely as possible to that of the natural joint in order to minimise any unnatural loading of other body parts and organs owing to wrong motions or a wrong position of the joint. Secondly, insertion and location of the parts of the prosthesis in the natural bones should allow maximum preservation of the bones, that is to say only the absolute minimum of bone substance should be removed from the bones for the insertion of the prosthesis.

Complying with the above mentioned requirements gives rise to substantial difficulties in the case of a knee joint prosthesis, for two reasons. Firstly, the motion of the natural knee joint is relatively complex because, as the knee is bent during walking, not only does the tibia pivot relative to the femur but also the pivot point shifts relative to the femur as the knee bends further. This shifting of the pivot point is accompanied by sliding of the bearing surfaces of the tibia and of the femur relative to one another and helps to reduce the effective length of the leg as it swings forwardly to prevent the toe catching on the ground. Secondly, the joint surfaces of the natural femur and tibia are relatively shallow condyles and cups respectively and are retained relative to each other merely by externally extending lateral ligaments.

It is an object of the invention to provide a prosthesis in which the bending motion of the knee coupled with sliding of the tibia relative to the femur is made possible without resulting in a construction which occupies too much space for a knee implant.

According to the present invention, a prosthetic implant for a knee joint comprises an upper part having an elongate anchorage portion adapted to be attached to a femur and a lower part having an elongate anchorage portion adapted to be attached to a tibia, one of the parts having a pair of bearing surfaces and a web portion projecting therebetween, the other part being formed with a corresponding pair of bearing surfaces and with a fork portion, the arms of which lie one on each side of the web portion of the said one part with the bearing surfaces on the said one part cooperating with the bearing surfaces on the said other part, and the web portion being provided with a slot at least part of which extends at an oblique angle to the axis of the anchorage portion of the said one part and accommodates a guide pin attached to the said other part. Preferably, the said one part is the lower part, and the bearing surfaces of the upper part are carried by the arms of the fork portion. The portion of the slot nearer the bearing surfaces of the said one part may extend substantially parallel to the axis of the anchorage portion of the said one part, the slot being curved.

The movement of the guide pin in the slot and therefore the movement of the entire joint may be greatly facilitated if the parts are so shaped that the guide pin is relieved of load-bearing stresses.

The movement of the joint may also be made easier if at least some of the facing surfaces of the web portion and of the arms of the fork portion are spaced apart by plastics bearing elements. Preferably the bearing elements are carried by the web portion. The bearing surfaces of one of the parts may be provided with a surface stratum of plastics; this also makes the movement easier.

The invention may be carried into practice in various ways, and one embodiment will now be described by way of example, with reference to the accompanying drawings, of which:—

Figure 1 is a side view of the upper part of a knee joint prosthesis;

Figure 2 is a view of the upper part as seen in the direction of the arrow A of Figure 1;

Figure 3 is a side view of the lower part of the prosthesis;

Figure 4 is a view of the lower part in the direction of the arrow B of Figure 3;

Figure 5 is a plan view of the lower part of the prosthesis; and

Figures 6 and 7 show the assembled prosthesis in the extended position and in the bent position respectively of the knee joint, the upper part being partially sectioned.

Terms such as "upper", "lower", "vertical" and "horizontal" will be used in this description as if the patient were standing erect.

The upper part of the prosthesis is provided with an elongate shank 1, which is adapted to anchor the upper part in the femur and is shown in full in Figures 6 and 7. The shank 1 tapers towards its free end, and is cruciform in cross-section, with rounded edges 2. The shank 1 merges into a fork 3 having discoid arms 5 which are provided with supporting plates 4 having supporting surfaces 6. In side elevation the shape of the supporting surfaces 6 of the supporting plates 4 is a curve composed of a plurality of circular arcs of different radii and different centres; this curve approximately and purely empirically simulates the joint surfaces of a natural femur in size and shape, the dimensions being obtained, for example, as the mean value of the dimensions, taken from X-ray photographs, of a plurality of natural joints. Some adjustment may be made in the dimensions to permit rolling of the upper part on the lower part as far as possible without any shocks or impacts.

The discoid arms 5 of the fork 3 are provided with a bore 7 the position of which is experimentally determined. The bore 7 is provided to accommodate a guide pin 8 (Figures 6 and 7).

The lower part of the prosthesis is provided with an elongate shank extension 10, the construction of which is similar to that of the shank 1 of the upper part and is intended for anchoring in the tibia; rotation of the shank 10 in the tibia is prevented by a triangular web 12. The shank 10 is provided at its top end with a plate 11; the upper surface of the plate 11 provides two bearing surfaces 9 which are of cylindrical form, as can be seen in side elevation, for the sake of simplicity and by analogy to the surface of the natural tibia. The supporting surfaces 6 of the top part roll slidingly on the bearing surfaces 9 during bending and extension of the knee joint.

A web 14 projects upwards from the upper surface of the plate 11, between the two surfaces 9, and, in the assembled knee joint, lies between the two discoid arms 5 of the upper part. The web 14 is provided with a slot 15 which extends generally rearwardly and upwardly; it is approximately kidney shaped with a rearward curvature. At its front it has an opening through which the guide pin 8 is inserted into the slot 15 during the implantation operation. A closing member 16 is inserted into the opening after the guide pin 8 of the top part has been inserted and is secured by means of screws 17 which are inserted into tapped holes in the web 14.

Both parts of the prosthesis are constructed of one of the known metal alloys which have already proved themselves for prosthetic implants and which consist mainly of cobalt, chromium, nickel and molybdenum.

Three bearing elements 18, for example of polyester, are inserted into bores in the web 14 and are retained by press fit by virtue of their elasticity. Furthermore, two members 19 which are constructed of plastics are embedded in the rolling surfaces 9, one on each side of the web 14, and are located in their correct position by pins 20 and anchored in the plate 11 by screws 21. The purpose of the plastics elements 18 and 19 is to prevent, or at least substantially reduce, the friction between the two metal parts which move relative to each other. The elements 19 also provide a certain resilience and damping between the two parts of the prosthesis, more particularly when it is loaded.

As shown by Figure 6, when the knee is extended, the guide pin 8 is disposed in the forward, lower part of the slot 15; during the bending motion, the pin 8 initially travels generally vertically upwards in the slot 15 until the joint has bent through 90°. If the knee is bent beyond 90°, the pin 8 will be displaced upwardly and towards the rear; this substantially simulates the motion of the natural knee. Very large bending motions are accompanied by separation of the surfaces 6 and 9. The previously mentioned sliding displacement of the tibia relative to the femur is obtained by virtue of the two surfaces 6 and 9 being unable to roll without sliding upon each other because the pin 8 is guided in the slot 15; instead they perform a simultaneous relative sliding motion during rolling. An even closer approach to the natural motion can be obtained in the range of bending up to 90° if the lower part of the slot is not vertical but extends upwards and towards the front, only the upper part of the slot being curved towards the rear. Thus the sliding displacement performed by the natural knee joint between the femur and the tibia is reproduced by the prosthesis without recourse to complicated structures which are provided with a plurality of shafts and springs of the kind commonly employed in the construction of external prostheses.

The dimensions of the individual elements, for example, the distance of the slot 15 and the guide pin 8 from the rolling or supporting surfaces 9 or 6 respectively are matched to each other in such a way that the weight is transferred by the supporting plates 4 of the

upper part to the bearing surfaces 9 of the lower part. This allows the pin 8 to be more accurately guided in the slot 15 than if the body weight bearing on the joint were transmitted by the pin 8 and the slot 15.

As already mentioned, it is important for reliable functioning of the prosthesis that the position of the guide pin 8 in the arms 5 of the fork 3 of the top part, the position of the slot 15 in the web 14, and the size and shape of the supporting surfaces 6 and the rolling surfaces 9 be determined to optimum values. All these parameters are therefore determined by model tests based on natural knee joints and progressively approximating the latter as closely as possible. Advantageously, mean values of the parameters can be determined from a plurality of natural joints. To this end, the centre of the bore 7 and of the guide pin 8 in the bore is positioned on the basis of the requirement that the axis of the pin 8 is disposed approximately at the pivoting point of a natural joint and performs a minimum motion which is steadily upwardly orientated when the knee is bent, that is to say when the surfaces 6 and 9 roll slidingly upon each other.

For example, the shape of the curve of the supporting surfaces 6 of the upper part consists of three different circular arcs, the arc with the largest radius corresponding to the shape in side elevation of the rolling surfaces 9 of the lower part. An arbitrary value of 10 mm, which is, however, sensible in terms of the overall dimensions for reasons of mechanical strength, is used for the diameter of the guide pin.

Having decided the shape of the supporting surfaces 6, the position of the guide pin 8 in the upper part and the radius of the rolling surfaces 9 of the lower part, the shape and position of the slot 15 is then determined by finding the position of the centre of the bore 7 on the web 14 in the extended position and in a number of other positions as the joint is progressively bent with the supporting surfaces 6 rolling and sliding upon the circular surfaces 9 of the lower part. The curve described by the centre will then be the centre line of the slot 15 from which the shape of the slot is determined. The width of the slot corresponds to the diameter of the pin 8 with a slight positive tolerance; the slot 15 is slightly extended in the downward direction as shown in Figure 6, so that load-bearing stresses are reliably prevented from reaching the guide pin 8.

WHAT WE CLAIM IS:—

1. A prosthetic implant for a knee joint comprising an upper part having an elongate anchorage portion adapted to be attached to a femur and a lower part having an elongate anchorage portion adapted to be attached to a tibia, one of the parts having a pair of bearing surfaces and a web portion projecting therebetween, the other part being formed with a corresponding pair of bearing surfaces and with a fork portion, the arms of which lie one on each side of the web portion of the said one part with the bearing surfaces on the said one part cooperating with the bearing surfaces on the said other part, and the web portion being provided with a slot at least part of which extends at an oblique angle to the axis of the anchorage portion of the said one part and accommodates a guide pin attached to the said other part.

2. An implant as claimed in claim 1 in which the said one part is the lower part, and the bearing surfaces of the upper part are carried by the arms of the fork portion.

3. An implant as claimed in claim 1 or claim 2 in which the portion of the slot nearer the bearing surfaces of the said one part extends substantially parallel to the axis of the anchorage portion of the said one part, and the slot is curved.

4. An implant as claimed in claim 1 or claim 2 or claim 3, in which the parts are so shaped that the guide pin is relieved of load-bearing stresses.

5. An implant as claimed in any preceding claim, in which at least some of the facing surfaces of the web portion and of the arms of the fork portion are spaced apart by plastics bearing elements.

6. An implant as claimed in Claim 5 in which the bearing elements are carried by the web portion.

7. An implant as claimed in any preceding claim in which the bearing surfaces of one of the parts are provided with a surface stratum of plastics.

8. A prosthetic implant for a knee joint substantially as herein described, with reference to the accompanying drawings.

KILBURN & STRODE,
Chartered Patent Agents,
Agents for the Applicants.

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1409150 COMPLETE SPECIFICATION

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Sheet 1

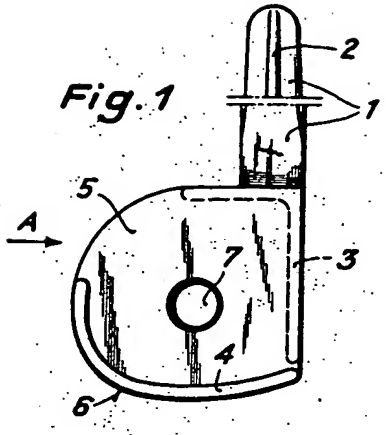

Fig. 1

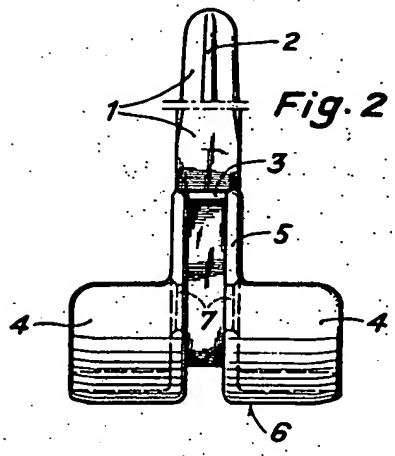

Fig. 2

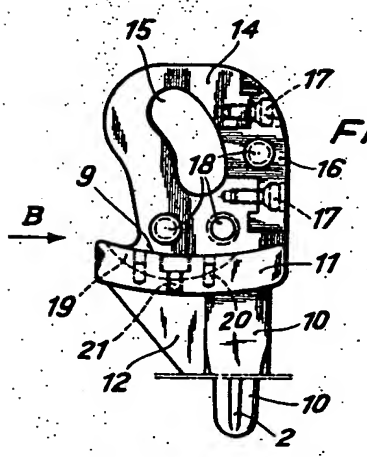

Fig. 3

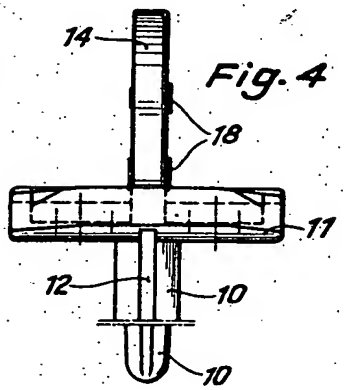

Fig. 4

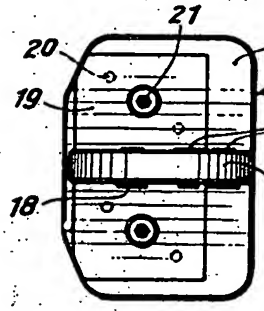

Fig. 5

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Sheet 2

Fig. 6

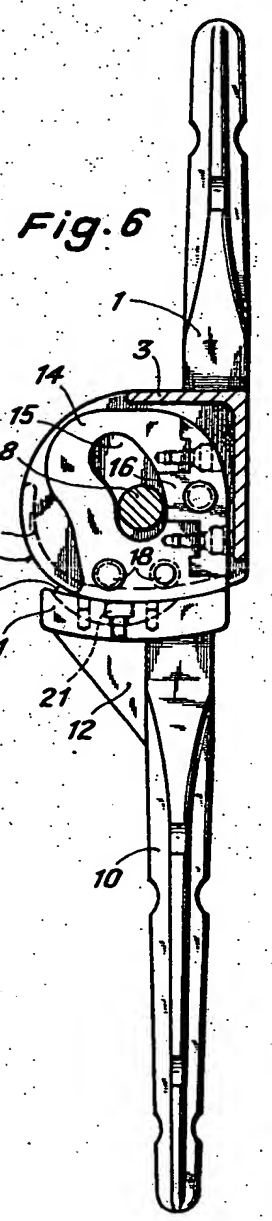

Fig. 7